PERGAMON

Vision Research 39 (1999) 3049–3056

Vision Research

www.elsevier.com/locate/visres

Sensitivity to horizontal and vertical corrugations defined by binocular disparity

Mark F. Bradshaw *[,1], Brian J. Rogers

Department of Experimental Psychology, University of Oxford, South Parks Road, Oxford OX1 3UD, UK

Received 8 April 1998; received in revised form 23 November 1998

Abstract

Sensitivity to corrugations defined by binocular disparity differs as a function of the modulation frequency. Such functions have proved to be useful descriptive and analytical tools in the study of the mechanisms involved in disparity processing. Indeed, given certain assumptions, these sensitivity functions can be used to predict certain perceptual outcomes. Given their importance, it is surprising that there is no comprehensive data set of disparity sensitivity functions (DSF) for a range of observers over a broad range of spatial frequencies and orientations. Here we report DSFs for six observers over an eight octave range of sinusoidal corrugations in disparity (0.0125–3.2 cpd). Multi-cycle, low frequency surfaces were used to assess the degree to which the fall-off in sensitivity at low corrugation frequencies is attributable to the decreasing number of cycles displayed. The data was found to form a continuous function despite the different number of cycles displayed. We conclude that the fall off in sensitivity is due to the spatial interactions in disparity processing. We also determined DSFs for the same observers to both vertically and horizontally oriented sinusoidal disparity corrugations in order to characterise the extent of the stereoscopic anisotropy In general, the best thresholds for detecting vertically oriented disparity corrugations were higher (~ 4 arc sec) than for horizontally oriented corrugations (~ 2 arc sec). Moreover, the functions were shifted toward the high spatial frequency end of the spectrum.

Keywords: Binocular disparity; Thresholds; Stereoscopic anisotropy

1. Introduction

Sensitivity for perceiving disparity-defined sinusoidal corrugations as a function of corrugation frequency is usually found to be best at intermediate frequencies and to be poorer for both higher and lower frequencies. For horizontally oriented corrugations, sensitivity is best at around 0.2–0.4 cpd and decreases substantially when the corrugation frequency is above 1 cpd or below 0.1 cpd (see Tyler, 1974; Rogers & Graham, 1982). This disparity sensitivity function (DSF) bears certain similarities with the CSF found in the spatial contrast domain although peak sensitivity is shifted towards lower frequencies by about an order of magnitude. The fall off in sensitivity for high frequency modulations (> 3.2 cpd) defines the upper resolution limit of binocular stereopsis. At higher frequencies depth transparency, rather than depth modulation, is apparent. The fall off in sensitivity for low frequency corrugations is usually taken as evidence for spatial interactions in disparity processing (e.g. Tyler & Julesz, 1978; Schumer & Ganz, 1979). Indeed Tyler (1991) provides an explicit interpretation of this fall off in sensitivity in terms of lateral inhibition within receptive fields in the disparity domain. Like its luminance counterpart the CSF, the DSF can also be used to predict or explain perceptual outcomes in certain circumstances. For example our susceptibility to the disparity version of the Craik-O'Brien-Cornsweet illusion (Anstis, Howard & Rogers, 1978) can be explained in terms of our relative insensitivity to low frequency information, as revealed by the DSF. The disparity sensitivity function therefore, like the CSF, has proved to be a useful descriptive and analytical tool in the investigation of stereoscopic vision.

* Corresponding author. Fax: +44-0148-3532813.
E-mail address: m.bradshaw@surrey.ac.uk (M.F. Bradshaw)
[1] Present address: Department of Psychology, University of Surrey, Guildford, GU2 5XH, UK.

PII: S0042-6989(99)00015-2

Given the importance of the DSF in our theoretical understanding of stereoscopic processing it is perhaps surprising that such a limited amount of data exists in the literature to define it. Therefore, a prime goal of the present paper was to address this deficit by determining the DSF across an entire eight octave range for six subjects (including two naive observers). In doing so we also address a potential artefact in that the fall-off in sensitivity at low frequencies, observed by Rogers and Graham (1982) may also be due to the decreasing numbers of cycles of depth modulation on the screen. With typical sizes of display, stimuli with corrugation frequencies below 0.1 or 0.05 cpd usually contain less than one complete cycle of disparity modulation. This attenuates the power in the disparity signal and therefore may contribute to the fall off in performance. Although this issue has already been addressed in the spatial contrast domain (see for e.g. Estevez & Cavonius, 1976; Howell & Hess, 1978; Robson & Graham, 1981) it has still not been resolved fully in the disparity domain (but see Tyler, 1974; Rogers & Graham, 1985). One reason for this is that the envelope of the DSF is centred at a much lower frequency than the CSF so that very large displays are required if multiple cycle low frequency stimuli are to be displayed at regular viewing distances. This is an important issue as the description of the bandpass characteristics of the disparity system (with its implications for the encoding of absolute or relative disparities) may be questionable. For this paper we used a large screen stereoscope with 80° fields to display multi-cycle low frequency surfaces (between 0.1 and 0.025 cpd). This equipment also allowed us to extend the DSF at the low frequency end of the spectrum to one cycle in 80° or 0.0125 cpd: a hitherto unexplored region of modulation frequency. In fact, a total of three displays were used which traded off pixel size (i.e. number of pixels which define a particular cycle of the disparity modulation) and overall screen size. In this way we could also display high frequency corrugations up to 3.2 cpd. In each of the displays the disparity was created using an analogue technique so that smooth, continuous surfaces, modulated in depth, could be displayed without the loss of spatial resolution often evident in digital displays which specify sub-pixel displacements/disparities using standard anti-aliasing techniques (e.g. Georgeson, Freeman & Scott-Samuel, 1996).

These experiments also provide the first published data on the DSF for vertically oriented corrugations and hence to compare the differences between the perception of horizontal and vertical corrugations for our six different observers. Our interest in this stems from the well known anisotropy in the perception of suprathreshold stereoscopic surfaces where it has been shown that disparity defined surfaces which slant or curve around a horizontal axis are seen more readily and with more apparent depth than surfaces which slant or curve around a vertical axis (e.g. Wallach & Bacon, 1976; Rogers & Graham 1983; Gillam, Flagg & Finlay, 1984; Gillam, Chambers & Russo, 1988; Parton, Bradshaw, Rogers & Davies, 1996). The spatial extent of interpolation processes in both directions may also differ (Yang & Blake, 1995). The anisotropy is also a feature of threshold measurements where it has been found that thresholds for surfaces which slant or curve about a horizontal axis are generally lower than their vertically oriented counterparts (e.g. Mitchison & McKee, 1990; Cagenello & Rogers, 1993; Parton et al., 1996). However, although it has been noted in both suprathreshold and threshold experiments that large individual differences may exist there is no published data comparing the DSFs for horizontally and vertically oriented corrugations in the same observers.

Therefore, the aim of the present experiments was to determine the visual system's sensitivity to sinusoidal depth corrugations over a wide range of spatial frequencies and to investigate the differences in sensitivity for detecting corrugated surfaces as a function of their orientation.

2. Method

2.1. Subjects

Six subjects took part in the experiments. Four were experienced psychophysical observers and two were not. All had normal or corrected to normal visual acuity.

2.2. Apparatus

To display a large range of corrugation frequencies the joint requirement of large displays (for low spatial frequencies) and resolution (for high spatial frequencies) was met by using three separate experimental rigs. In each case, binocular disparities were generated by one of two analogue techniques which permitted infinitely small, sub-pixel disparities of finely focused dots to be displayed. Hence, smooth continuous modulations in depth could be displayed. The electronic techniques have been described extensively before and so only a brief overview is given here. For further details see Rogers and Graham (1982), set-up I and II and Bradshaw and Rogers (1996), set-up III.

2.3. Stimuli

The stimuli were 50% random dot patterns, 240 × 240 pixels, visible within a circular aperture of 10, 20 or 80° diameter. Dot separation was either 2.5, 5 or 20 arc min. The pattern of random dots was changed on each experimental trial. Two horizontal white lines 12 pixels long (0.5, 1 and 4°) placed in the stimulus at the perimeter of each display marked the central corrugation. Viewing distance was set at 57 cm and care was taken to ensure that the angle of convergence was appropriate for fixation at this distance.

There is an inherent confound in the generation of horizontal modulations of disparity (to create vertically oriented corrugations) with the disparities themselves. Through the compression and expansion of the base noise patterns, density variations arise which may become visible to the monocular observer if the magnitude of the disparity is large. Tyler and Raibert (1975), however, showed that the visibility of these density variations is well below disparity thresholds for most of the measurement range. We confirmed this result in our own pilot experiments. Moreover, in some trials where relatively large disparities were used, in the attempt to obtain a threshold for two observers with low frequency corrugations, no threshold could be determined. This suggests that even where the density variations were greatest they were not used in the performance of our experimental task.

2.4. Experimental set-up I and II

Dichoptic presentation of the same pattern of random dots, generated on a Macintosh IIx computer, was achieved using two displays, viewed separately by each eye, via mirrors arranged in a modified Wheatstone configuration. Either two Tektronix 604 or two Hewlett Packard HP1304A display oscilloscopes were used to display the patterns. The visual extent of the stimuli was 10 or 20° for the Tektronix 604 and HP1304A displays respectively. In both cases binocular disparities were created by introducing *equal and opposite* shifts to the dots on the two display oscilloscopes with analogue signals, generated by a Wavetek 175 and applied to an additional X input on the scopes. To present horizontally oriented corrugations, the shifts were applied to each horizontal raster line (creating a shear transformation). To present vertically oriented corrugations, the X and Y raster scans were reversed so the same *horizontal* shift, created by the additional X input, was applied to each vertical raster (creating a compression/expansion transformation). Further details of the techniques involved can be found in Rogers and Graham (1982). The temporal frequency of the additional X signal was varied to create different corrugation frequencies.

On the Tektronix displays the corrugations frequency was varied between 0.9 cpd (9 complete cycles on the screen) and 3.2 cpd (32 complete cycles). Thresholds were measured for corrugation frequencies of 0.9, 1.6, and 3.2 cpd. On the HP1304A displays, the corrugation frequency was varied between 0.057 cpd (1.1 complete cycle on the screen) and 1.559 cpd (31 complete cycles). Thresholds were measured for corrugation frequencies of 0.057, 0.1, 0.17, 0.3, 0.5, 0.9 and 1.559 cpd.

2.5. Experimental set-up III

The same stimulus configuration was presented within a circular aperture of $\sim 80°$ diameter. The subject was seated at the centre of a cubic frame (each side 114 cm). The stimuli were rear-projected using Electrohome EDP 58 video projectors onto screens of translucent Mylar mounted on the left and right of the subject and viewed dichoptically by front-silvered mirrors arranged in a Wheatstone configuration (see Rogers & Bradshaw, 1995). Binocular disparities were generated by phase shifting (via 2 Wavetek 178's) the video signal on two Apple Macintosh Video cards resident in a Macintosh IIfx (see Bradshaw & Rogers, 1996). Equal and opposite shifts were applied to each horizontal raster of the two video cards and so only horizontal corrugations could be produced by this technique. Corrugation frequency was varied between 0.0125 cpd (one cycle on the screen) and 0.1 cpd (eight complete cycles). Thresholds were measured for corrugation frequencies of 0.0125, 0.25, 0.05, and 0.1 cpd.

2.6. Experimental method

The method of constant stimuli was used to determine threshold performance. By pressing one of two response keys the observer's task was to report whether the corrugation at the centre of the dot pattern, and marked by the two white lines, was concave (a trough) or convex (a peak). On each trial, the amplitude of the disparity signal was randomly chosen from seven possible values corresponding to -3, -2, -1, 0, 1, 2 or 3 times the step size. The sign of the disparity determined whether the central corrugation was a peak or a trough. The magnitude of the step size for each condition was chosen in pilot trials. An experimental session consisted of 280 trials (in four blocks), corresponding to 40 trials at each of the seven amplitude levels. Frequency of seeing plots were generated from each data set and the best-fitting cumulative gaussian curve was determined using the probit technique (Finney, 1971). The 75% point on the psychometric function was taken as the threshold value. Each observer completed blocks in random order over the course of 7–10 days.

3. Results and discussion

Fig. 1 plots disparity thresholds (arc sec) for horizontally oriented corrugations as a function of spatial frequency (cpd) for each of the six observers separately. Thresholds from the different experimental set-ups are shown by different symbols.

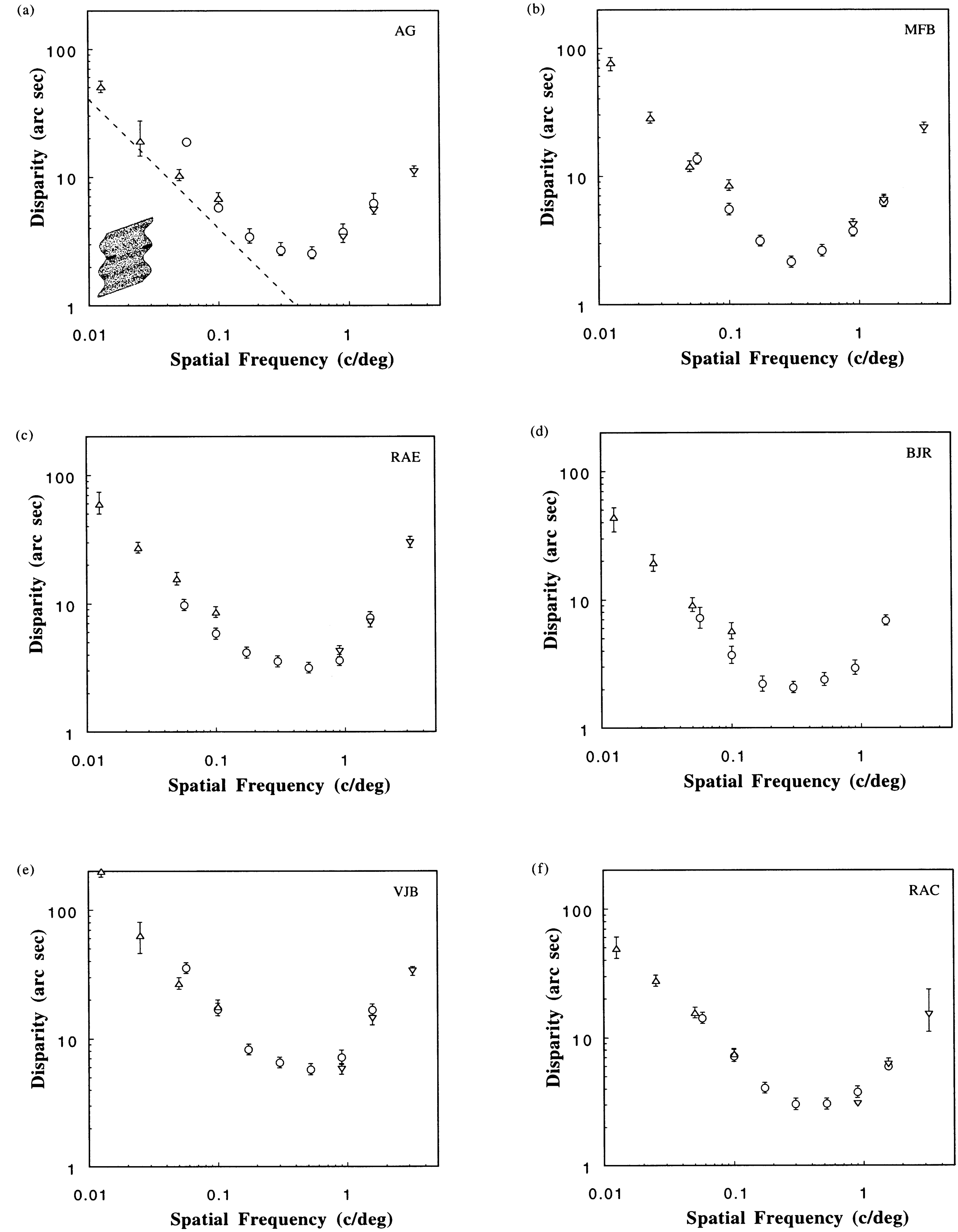

Fig. 1. The DSFs for horizontal sinusoidal modulations for each observer plotted separately (a to f). The ordinate represents thresholds in arc sec, and the abscissa represents modulation frequency in cpd. The different symbols represent thresholds determined using the different experimental set-ups. Upward pointing triangles represent the 80° displays; the open circles represent the 20° displays and the downward pointing triangles represent the 10° displays. The hatched line shown in (a) indicates a slope of −1.

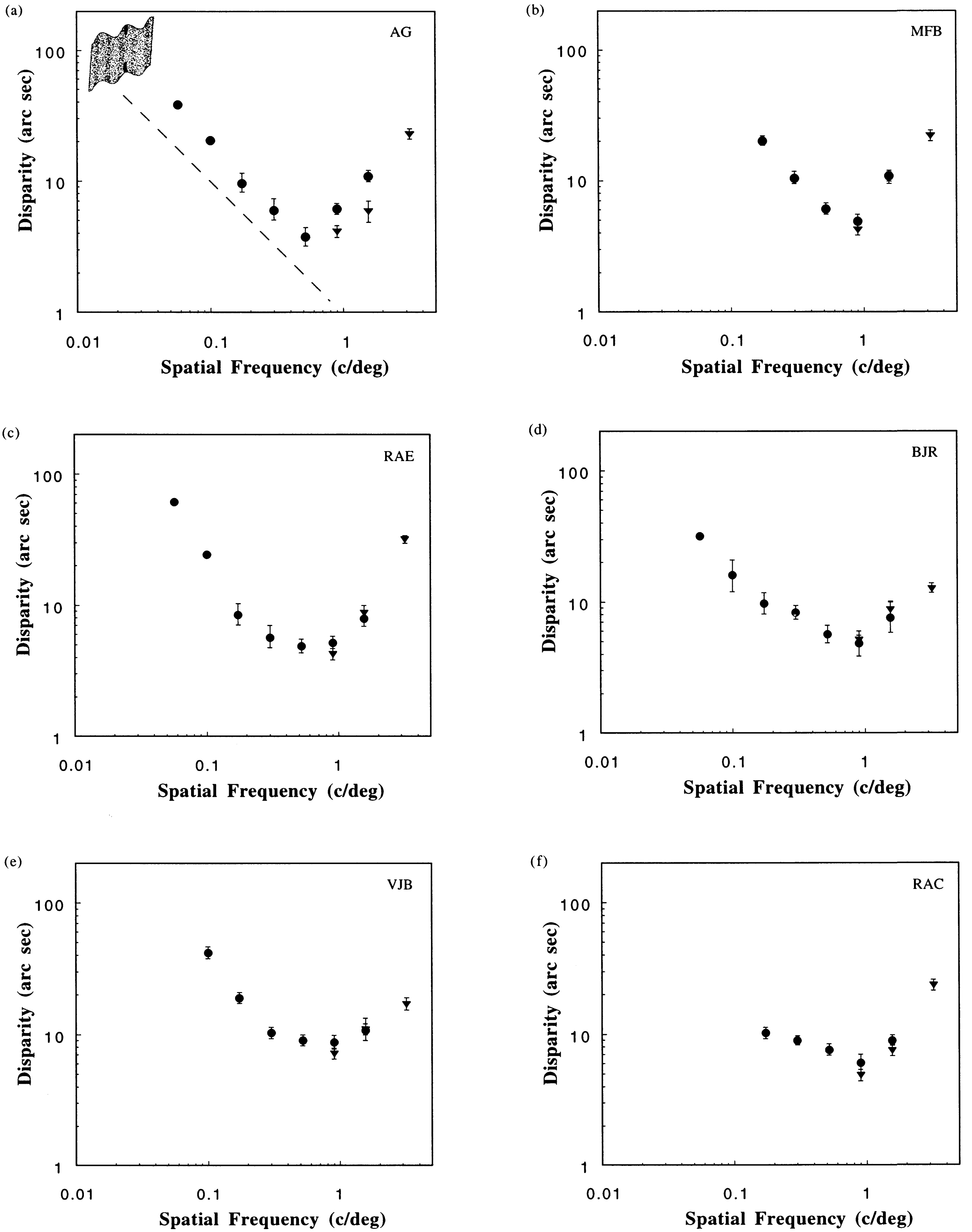

Fig. 2. The DSFs for vertical sinusoidal modulations for each observer plotted separately (a to f). The ordinate represents thresholds in arc sec, and the abscissa represents modulation frequency in cpd. The closed circles represent the 20° displays and the triangles represent the 10° displays. The hatched line shown in 1(a) indicates a slope of -1.

The minimum threshold (maximum sensitivity) for all observers was found for corrugation frequencies of between 0.3 and 0.5 cpd. Thresholds increased for both higher and lower spatial frequencies. For three of the experienced observers, the lowest thresholds were around 2 arc sec peak-to-trough disparity (at 0.3 cpd) which corresponds to a depth difference between the peaks and troughs of the corrugations of less than 1/20 mm (about the thickness of a sheet of paper) at 57 cm. These results confirm and extend those previously reported by Tyler (1974) and Rogers and Graham (1982) although the absolute thresholds determined with the present procedure are about an order of magnitude lower. The magnitude of the thresholds is comparable with other estimates of stereo-acuity under a range of different conditions which have typically been found in the range of 2–6 arc secs (see Howard & Rogers, 1995 pg. 149). The bandwidth of these DSF envelopes were similar for five of the six observers at about four octaves. The bandwidth of the envelope of the other observer (MFB) was about three octaves.

As can be seen in Fig. 1, the data from the different experimental set-ups form a continuous function despite the different number of cycles displayed. The fall-off in sensitivity at low spatial frequencies (<0.01 cpd), therefore, cannot be attributable *solely* to the reduction in the number of cycles on the screen which is consistent with the findings in the contrast domain (Estevez & Cavonius, 1976) and in the disparity domain. Tyler (1974) compared directly sensitivity for single and multi-cycle modulations of disparity (with differently sized apertures) over a range of modulation frequencies. Using stereograms of a single vertical line modulated in depth he found sensitivity for multi-cycle modulations (above 0.1 cpd) was greater than for single cycles, and that the major portion of this benefit was accrued with just two cycles (cf Fig. 4, Tyler, 1974). This indicates the spatial integration limit of the system. The fall off in sensitivity at low spatial frequencies, evident in Fig. 1, approximates to a slope of -1. (A slope of -1 is indicated by the hatched line in Fig. 1a.) This shows that as the spatial period is doubled, the peak-to-peak disparity must also be doubled to maintain threshold performance. This is characteristic of spatial mechanisms limited by rate of change (or spatial gradient) of disparity and is presumably due to spatial inhibition within the cyclopean domain (see Tyler, 1991; Norman, Lappin & Zucker, 1991).

Fig. 2 plots disparity thresholds (arc sec) as a function of spatial frequency (cpd) for each of the 6 observers separately for the vertically oriented corrugations. The fall-off in sensitivity is much more rapid at low spatial frequencies compared to the fall off found with horizontally oriented corrugations. It was not possible to use experimental set-up III to collect data for vertical surfaces although, in the event, this was not crucial as thresholds rose substantially at frequencies below 0.1 cpd. In fact two of the observers (MFB and RAC) could not see these depth modulations at all when the corrugation frequency was below 0.173 cpd and a reliable estimate of the threshold could not be obtained. The second difference between performance on the horizontal and vertical corrugations was that the peak sensitivity for vertically oriented corrugations was shifted from between 0.3–0.5 cpd to between 0.7–0.9 cpd for five of the six observers. For AG peak frequency was the same for both orientations (0.5 cpd). Finally, the lowest thresholds for vertically oriented corrugations were on average 1.6 times higher than horizontal corrugations. Beyond 0.9 cpd, the relative sensitivity for vertical and horizontal corrugations is similar for five of the six observers. In fact, the sixth observer (VJB) was more sensitive to vertical than horizontal corrugations when corrugation frequency was above 1 cpd and her DSFs for the two orientations crossed over. A similar pattern of results was reported by Nakayama, Silverman, MacLeod and Mulligan, (1985) who investigated sensitivity to shearing and compressive motion at different spatial frequencies and found a much larger rise in thresholds for shear (corresponding to horizontally oriented corrugations) than compressive motion (corresponding to vertical corrugations) when modulations were above 1 cpd. The relative insensitivity to vertically oriented corrugations known as the stereoscopic anisotropy, is therefore a property of low corrugation frequencies only; the anisotropy disappears or is reversed for surfaces with high corrugation frequencies (see also Fig. 3). This pattern of results may account for some of the differences found in the

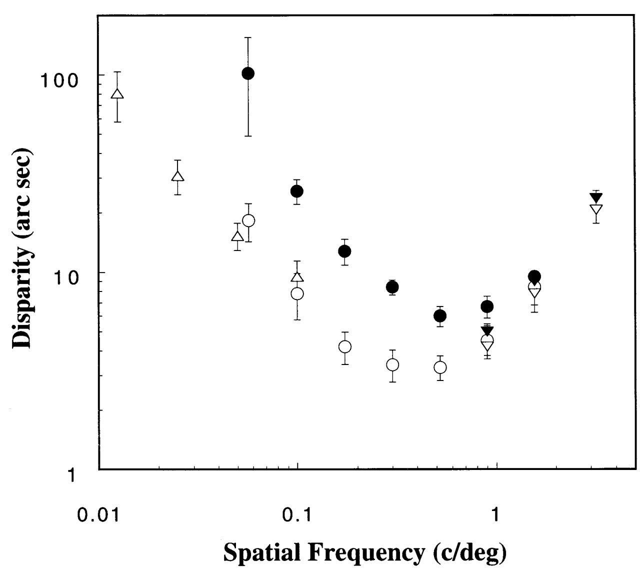

Fig. 3. A summary of the data presented in Figs. 1 and 2. The key is the same as the previous figures. Open symbols represent data from horizontally oriented corrugations and closed symbols represent vertically oriented corrugations.

literature in this area since different experiments have used different disparity defined surfaces (e.g. smooth curves versus hinged or ridged surfaces) and the different surfaces differ in the frequency of disparity components when viewed from the perspective of linear systems analysis (see for example Gillam et al., 1988). The bandwidths of the envelopes of the DSFs for vertically oriented corrugations were also calculated and found to be slightly narrower than their horizontal counterparts for two of the six observers whereas they were fairly similar ($\sim$ four octaves) for the other observers.

A satisfactory explanation for the stereoscopic anisotropy has not been established although it has been addressed in the literature frequently, and has also proved an useful analytic tool in the study of stereoscopic mechanisms (see Howard & Rogers, 1995 for a recent review). A summary of the data from all the observers for both orientations of the corrugations is given in Fig. 3.

The different properties of the DSFs for horizontal and vertical surfaces may explain why the disparity version of the Craik-O'Brien-Cornsweet illusion only induces a significant depth illusion when the orientation of the spur-shaped profile is vertical. Anstis et al. (1978) and Rogers and Graham (1983) attributed the illusion to the fact that the stereo system is relatively insensitive to the low spatial frequency changes in disparity on either side of the discontinuity. The anisotropy in the magnitude of the effect as a function of the orientation of the profile is consistent with the greater fall-off in sensitivity to low frequency vertical corrugations as found here. It would be interesting to relate the size of the illusion with the differences in DSFs found for several different observers and to display a large field version of the Craik-O'Brien-Cornsweet illusion (with very low depth modulations) with the spur oriented horizontally to see if the illusion was present under these conditions.

An important issue which has been addressed in the context of DSFs is whether they describe the operation of a single broadly tuned channel or whether it is the envelope of two or more independent channels. Using techniques drawn from spatial contrast vision such as masking and adaptation, the evidence supports the latter idea with bandwidths of the independent channels estimated to be between one and three octaves (Schumer & Ganz, 1979; Tyler, 1983; Cobo-Lewis & Yeh, 1994). A similar result has recently been found in the parallax domain (Hogervorst, Bradshaw & Eagle, 1998) where an analogous parallax sensitivity function has been reported (Rogers & Graham, 1982).

In summary, this paper provides a comprehensive set of data which describe the sensitivity of the stereo system to sinusoidal modulations of disparity in two orientations: horizontal and vertical. Sensitivity functions have proved important descriptive and analytical tools in the luminance, disparity and motion parallax domains. For horizontally oriented disparity corrugations, peak sensitivity occurs between 0.3 and 0.5 cpd and falls off for higher and lower spatial frequencies. The spatial tuning function for vertically oriented corrugations differed in two respects: (i) absolute thresholds were higher and; (ii) the function was shifted, towards the higher corrugation frequencies. The stereoscopic anisotropy (the relative insensitivity to vertical corrugations) was found to be a characteristic of low frequency corrugations only.

Acknowledgements

The present work was supported by an Esprit Basic Research Grant 6019 and SERC (UK). A preliminary version of the results described in this paper were presented at ECVP 1993. We wish to thank Richard A. Eagle and Andrew Glennerster for their help in the preparation of this paper.

References

Anstis, S. M., Howard, I. P., & Rogers, B. J. (1978). A Craik-O'Brien-Cornsweet illusion for visual depth. *Vision Research*, *18*, 213–217.

Bradshaw, M. F., & Rogers, B. J. (1996). The combination of stereo and motion information. *Vision Research*, *36*, 3457–3468.

Cagenello, R. B., & Rogers, B. J. (1993). Anisotropies in the perception of stereoscopic surfaces: the role of orientation disparity. *Vision Research*, *33*, 2189–2201.

Cobo-Lewis, A. B., & Yeh, Yei-Yu (1994). Selectivity of cyclopean masking for the spatial frequency of binocular disparity modulation. *Vision Research*, *34*, 607–620.

Estevez, O, & Cavonius, C. R. (1976). Low-frequency attenuation in the detection of grating: sorting out the artefacts. *Vision Research*, *16*, 497–500.

Finney, D. J. (1971). *Probit analysis* (3). Cambridge: Cambridge University Press.

Georgeson, M. A., Freeman, T. C. A., & Scott-Samuel, N. E. (1996). Sub-pixel accuracy: psychophysical validation of an algorithm for fine positioning and movement of dots on visual displays. *Vision Research*, *36*, 605–612.

Gillam, B., Chambers, D., & Russo, T. (1988). Postfusional latencies in stereoscopic perception and the primitives of stereopsis. *Journal of Experimental Psychology*: *Human Perception and Performance*, *14*, 163–175.

Gillam, B., Flagg, T., & Finlay, D. (1984). Evidence for disparity change as the primary stimulus for stereoscopic processing. *Perception and Psychophysics*, *36*, 559–564.

Hogervorst, M. A., Bradshaw, M. F., & Eagle, R. A. (1998). Evidence for independent channels in the perception of motion-parallax defined surfaces. *Perception*, *27*, 113.

Howard, I. P., & Rogers, B. J. (1995). *Binocular vision and stereopsis*. New York: OUP.

Howell, E. R, & Hess, R. F. (1978). The functional area for summation to threshold for sinusoidal gratings. *Vision Research*, *18*, 369–374.

Mitchison, G. J., & McKee, S. P. (1990). Mechanisms underlying the anisotropy of stereoscopic tilt perception. *Vision Research*, *30*, 1781–1791.

Nakayama, K, Silverman, G. H., MacLeod, D. I. A., & Mulligan, J. (1985). Sensitivity to shearing and compressive motion in random dots. *Perception*, *14*, 225–238.

Norman, J. F., Lappin, J. S., & Zucker, S. W. (1991). The discriminability of smooth stereoscopic surfaces. *Perception*, *20*, 789–807.

Parton, A. D., Bradshaw, M. F., Rogers, B. J., & Davies, I. R. L. (1996). The effect of surface orientation on the perception of stereoscopic corrugations. *Perception*, *25*, 67.

Robson, J. G, & Graham, N. (1981). Probability summation and regional variation in contrast sensitivity across the visual field. *Vision Research*, *21*, 409–418.

Rogers, B. J., & Graham, M. E. (1982). Similarities between motion parallax and stereopsis in human depth perception. *Vision Research*, *22*, 261–270.

Rogers, B. J., & Graham, M. E. (1983). Anisotropies in the perception of three-dimensional surfaces. *Science*, *221*, 1409–1411.

Rogers, B. J., & Graham, M. E. (1985). Motion parallax and the perception of three-dimensional surfaces. In D. Ingle, M. Jeannerod, & D. Lee, *Brain mechanisms and spatial vision* (pp. 95–111). The Hague: Martinus Nijhoff.

Rogers, BJ, & Bradshaw, MF (1995). Disparity scaling and the perception of fronto-parallel surfaces. *Perception*, *24*, 155–180.

Schumer, R., & Ganz, L. (1979). Independent stereoscopic channels for different extents of spatial pooling. *Vision Research*, *19*, 1303–1314.

Tyler, C. W. (1974). Depth perception in disparity gratings. *Nature*, *251*, 140–142.

Tyler, C. W., & Raibert, M. (1975). Generation of random-dot stereogratings. *Behaviour Research Methods and Instrumentation*, *7*, 37–41.

Tyler, C. W. (1991). Cyclopean vision. In D. Regan, *Vision and visual dysfunction*, *binocular vision*, vol. 9 (pp. 38–74). London: Macmillan.

Tyler, C. W., & Julesz, B. (1978). Spatial frequency tuning for disparity gratings in the cyclopean retina. *Journal of the Optical Society of America*, *68*, 1365.

Tyler, C. W. (1983). Sensory processing of binocular disparity. In C. M. Schor, & K. J. Cuiffreda, *Vergence eye movements: basic and clinical aspects* (pp. 199–295). London: Butterworths pp. 199–295.

Wallach, H., & Bacon, J. (1976). Two forms of retinal disparity. *Perception and Psychophysics*, *19*, 375–382.

Yang, Y., & Blake, R. (1995). On the accuracy of surface reconstruction from disparity interpolation. *Vision Research*, *35*, 949–960.